

Autonomous Robotic Weapons: US Army Innovation for Ground Combat in the Twenty-First Century

A Monograph

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Abstract

Autonomous Robotic Weapons: US Army Innovation for Ground Combat in the Twenty-First Century,
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This monograph analyzes three case studies and compares them to determine some of the critical factors behind models of successful and unsuccessful innovation. These case studies include the German and French Armies and their mechanized doctrine development 1919-1939 and the U.S. Army's autonomous robotic doctrine development 2005 – 2025. Contemporary operational planners, much like their predecessors in the inter-war period, must be attuned to the changing characteristics of warfare. These changes in the contemporary operational environment will likely incorporate autonomous robotic capabilities at an unprecedented pace. This project seeks to determine if maneuver officers in the US Army are fully anticipating the requirement to field and develop autonomous robotic ground weapon systems, and create a comprehensive doctrine to effectively integrate these systems with other emergent technologies. It further determines whether powerful institutional norms, rooted in decades of battlefield dominance throughout the twentieth century, have formed a cognitive resistance to such innovative doctrinal development or to paradigm shifts that may be required to prepare the US Army to dominate ground combat operations in the 21st century.

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Acronyms

ADS	Active Denial System
AFB	Air Force Base
AOC	Army Operating Concept
ARCIC	Army Capabilities Integration Center
ATHENA	Advanced Test High Energy Asset
BCT	Brigade Combat Team
BEAR	Battlefield Extraction Assist Robot
BOG	Boots-on-Ground
CAM	Combined Arms Maneuver
CBO	Congressional Budget Office
CBRNE	Chemical Biological Radiological Nuclear and Explosive
CIA	Central Intelligence Agency
CLARK	Common Light Autonomous Robotics Kit
COTS	Commercial-of-the-Shelf
CSI	Combat Studies Institute
CT	Counter Terrorism
DARPA	Defense Advanced Research Projects Agency
DEW	Directed Energy Weapons
DoD	Department of Defense
FLA	Fast Lightweight Autonomy
G-BAD DE	Ground Based Air Defense Directed Energy
HELLADS	High Energy Liquid Laser Area Defense System
HEL-TD	High Energy Laser Technology Demonstrator
HEMTT	Heavy Expanded Mobile Tactical Truck
IBM	International Business Machines Corporation

IED	Improvised Explosive Device
ITE	Integrated Training Environment
JBC-P	Joint Battle Command Platform
JGRIT	Joint Ground Robotics Integration Team
JLTV	Joint Light Tactical Vehicle
LaWS	Laser Weapon System
LOI	Levels of Integration
MAARS	Modular Advanced Armed Robotic System
MARCBot	Multi-function Agile Remote Control Robot
MIT	Massachusetts Institute of Technology
MUM-T	Manned Unmanned-Teaming
NIE	Network Integration Evaluation
OCO	Overseas Contingency Operations
OE	Operational Environment
OEF	Operation Enduring Freedom
OIF	Operation Iraqi Freedom
ONR	Office of Naval Research
PACOM	Pacific Command
POR	Program of Record
R&D	Research and Development
RSJPO	Robotic Systems Joint Project Office
SAFFiR	Shipboard Autonomous Firefighting Robot
SOUTHCOM	Southern Command
SWORDS	Special Weapons Observation Reconnaissance Detection System
TARDEC	Tank Automotive Research Development and Engineering Center

TRADOC	Training and Doctrine Command
UAV	Unmanned Aerial Vehicle
UAS	Unmanned Aerial Surveillance
UGS	Unmanned Ground Systems
ULO	Unified Land Operations
US	United States
USMC	United States Marine Corps
USS	United States Ship
WAS	Wide Area Security
WIN-T	Warfighter Information Network-Tactical
WWI	World War One
WWII	World War Two

Introduction

Today the robot is an accepted fact, but the principle has not been pushed far enough. In the twenty-first century the robot will take the place which slave labor occupied in ancient civilization. There is no reason at all why most of this should not come to pass in less than a century, freeing mankind to pursue its higher aspirations.¹

-Nikola Tesla, 1937

When, for these reasons or others like them, an anomaly comes to seem more than just another puzzle of normal science, the transition to crisis and to extraordinary science has begun. The anomaly itself now comes to be more generally recognized as such by the profession...For them the field will no longer look quite the same as it had earlier.²

-Thomas S. Kuhn, 1962

Secretary Rumsfeld once famously told a Soldier that you go to war with the army you have, which is absolutely true. But I would add that you damn well should move as fast as possible to get the army you need. That was the crux of my war with the Pentagon.³

-Secretary Robert M. Gates, 2014

The twenty-first century provides a challenging, complex, and dynamic operational environment for US military planners to effectively link tactical ways and means to achieve strategic ends and to ultimately enforce US national policy. The US Army's current Unified Action doctrine states that Unified Land Operations must be executed through decisive action, and by means of the two core competencies of combined arms maneuver and wide area security.⁴ This doctrine outlines a wide-ranging mission set for land component forces, and therefore maneuver officers will need to develop innovative solutions to effectively train and prepare Soldiers to rapidly respond to a variety of these world-wide contingencies. The recent US troop withdrawals from Iraq and Afghanistan, in conjunction with

¹ Matt Novak, "Nikola Tesla's Amazing Predictions for the 21st Century," Smithsonian.com, accessed March 26, 2015, <http://www.smithsonianmag.com/history/nikola-teslas-amazing-predictions-for-the-21st-century-26353702/?no-ist>.

² Thomas S. Kuhn, *The Structure of Scientific Revolutions*, 3rd ed. (Chicago, IL: University of Chicago Press, 1996), 82.

³ Robert M Gates, *Duty: Memoirs of a Secretary at War* (New York, NY: Knopf, 2014), 148.

⁴ *Army Doctrine Publication 3-0: Unified Land Operations* (Fort Leavenworth, KS: U.S. Army Combined Arms Center, October, 2011), 6.

subsequent reductions in national defense budgets, and lower force levels are congruent with a lack of overall popular support for the mass deployment of US combat Soldiers abroad. In the recent post-war environment, US military planners increasingly strive to develop innovative ways to achieve greater capabilities with fewer resources. Concurrently, many civilian applications and developments of both digital and robotic technology continue to advance at an unprecedented pace. The proliferation of this technology has rendered unmanned, remote controlled, and even autonomous robotic systems accessible to both state and non-state organizations alike. The potential applications for these robotic systems are continually expanding and their capabilities may be exploited for both benevolent and malevolent designs. Though many of these early robotic innovations manifested in Iraq and Afghanistan, the vast capabilities and growing implications of these armed robotic weapon systems have not yet been fully realized. It is useful to consider and compare the insights of genius-inventor Nikola Tesla who predicted extraordinary advancements in robotic capabilities for our near-term future, with the observations of former Secretary of Defense Robert Gates who cautioned against the stalwart resistance to change inherent within powerful military-industrial bureaucracies.

Based on these conditions, the contemporary operational environment contains significant parallels with the strategic environment of the early half of the interwar period 1919-1939, in three primary respects. These parallels include a general public sentiment and aversion to combat casualties, the rapid escalation of emergent technologies, and the uncertainty about the specific nature of armed conflict within the next decades. Military planners faced uncertainty about how to best integrate early model trucks, tanks, airplanes, and radio systems during the interwar period. Similarly, the United States Army may soon be challenged with refining its doctrine to best integrate the full capabilities of early model directed energy weapons, biometrics, supercomputing devices, autonomous robotic ground weapon systems, and UAS directly into ground combat operations.

Contemporary operational planners, much like their predecessors in the inter-war period, must be attuned to the changing characteristics of warfare. This shift will likely incorporate growing autonomous robot capabilities at an unprecedented pace. Are maneuver officers in the US Army fully anticipating the

fielding and development of these systems, and are they envisioning a comprehensive doctrine that will effectively integrate these systems with other emergent technologies? Or, have powerful institutional norms developed from decades of battlefield dominance in the twentieth century, formed a resistance to such an innovative doctrinal approach? The hypothesis here is that maneuver officers are not fully anticipating the requirement to train, equip, and fully integrate the force with autonomous robotic ground weapon systems, nor the potential paradigm changes that may emerge.

Three case studies form the basis for analysis, providing for their comparison to determine some of the critical factors behind models of successful and unsuccessful innovation. Successful innovation is defined here as the effective integration of emergent technological capabilities to transcend both contemporary paradigms, and accepted institutional norms in order to generate a superior method or practice for obtaining a position of relative operational and tactical advantage over an adversarial force. Thomas Kuhn's Theory of Scientific Revolutions provides criteria for contrasting the phenomena of innovation for each case study. Moore's Law and Kurzweil's Law of Accelerating Returns provide critical context for the phenomena of technological development for the third case study.

In his 1962 book, *The Structure of Scientific Revolutions*, philosopher Thomas Kuhn published his theory on how a given collection of accepted practices and procedures ultimately accumulates into what becomes viewed as normal science or into "puzzle-solving" paradigms.⁵ He argued that problems or "anomalies" will inevitably arise, which cannot be solved through the application of these paradigms, which causes normal science to then morph into periods of "revolutionary science" until such time as new scientific theories emerge with sufficient solutions to solve the anomalies.⁶ During these periods of "revolutionary science", Kuhn explains, heightened insecurities and perceptions of crisis often develop.⁷

⁵ "Stanford Encyclopedia of Philosophy," Stanford Encyclopedia of Philosophy, last modified August 11, 2011, accessed March 31, 2015, <http://plato.stanford.edu/entries/thomas-kuhn/#6.1>.

⁶ Kuhn, *The Structure of Scientific Revolutions*, 62.

⁷ Ibid., 68.

In fact, he summarizes, “Failure of existing rules is the prelude to a search for new ones”.⁸ Thomas Kuhn’s theory of scientific revolutions provides criteria through which to compare and contrast each case study to assess the relative perception of crisis and its impact on subsequent levels of successful innovation.

In his 1965 paper published in *Electronics Magazine*, Gordon Moore (cofounder of Intel) published his observation that the number of transistors on microchips doubled each year, (subsequently revised to every two years) which enables computer devices to become incrementally smaller while concurrently sustaining exponential increases in their processing speed and performance.⁹ For example, in 1964 a standard chip contained about 30 transistors each and by 2012 the Core i7 chips inside many laptops contained over 1.4 billion transistors each.¹⁰ Known as “Moore’s Law”, this trend has consistently held true over the last 5 decades and it is expected to continue for at least the next ten years.¹¹

Finally, in his 1999 book, *The Age of Spiritual Machines*, the distinguished author and accomplished computer scientist Ray Kurzweil (director of engineering at Google) published a list of seven observations known collectively as “The Law of Accelerating Returns” which explains how the rate of an evolutionary process increases exponentially over time.¹² Kurzweil provides additional context to this observation by explaining, “An analysis of history of technology shows that technological change is exponential, contrary to the common-sense ‘intuitive linear’ view. So we won’t experience 100 years of

⁸ Kuhn, *The Structure of Scientific Revolutions*, 68.

⁹ Stephen Shankland, “Moore’s Law: The Rule That Really Matters in Tech,” CNET, October 15, 2012, accessed March 31, 2015, <http://www.cnet.com/news/moores-law-the-rule-that-really-matters-in-tech/>.

¹⁰ Ibid.

¹¹ Ibid.

¹² Ray Kurzweil, “The Law of Accelerating Returns,” Kurzweil Accelerating Intelligence, March 7, 2001, accessed March 29, 2015, <http://www.kurzweilai.net/the-law-of-accelerating-returns>.

progress in the 21st century – it will be more like 20,000 years of progress (at today’s rate)”.¹³ Kurzweil’s Law of Accelerating Returns is considered into context during the third case study regarding the US Army’s present level of innovation with autonomous robotic ground weapon systems.

Three case studies form the core of the analysis of the hypothesis within the organization of the monograph. The first case study (part I) examines the German army during the interwar period to determine: first, the specific conditions that existed in Germany after the conclusion of the First World War, second, the decisions and actions taken by the military leadership to innovative with emergent technological capabilities of the period, and third, the subsequent results of their doctrinal development and its subsequent impact on operational and tactical success during the early months of the Second World War. The evidence indicates that the German army applied combat experience with technological education during the interwar period to create its mechanized doctrine of combined arms maneuver or *Bewegungskrieg* (“war of movement”).¹⁴

The second case study (part II) examines the French army during the interwar period to determine: first, the specific conditions that existed in France after the conclusion of the First World War, second, the decisions and actions taken by its military leadership to innovative with emergent technological capabilities of the period, and third, the subsequent results of their doctrinal development and its impact on operational and tactical failures during the early months of the Second World War. The evidence indicates that the French army leadership remained rooted in an obsolete paradigm that anticipated future war(s) of fortifications and attrition, and did not seek to innovate with emerging technological capabilities of the period. Although the French army continued to develop sophisticated

¹³ Ray Kurzweil, “The Law of Accelerating Returns,”.

¹⁴ Robert Citino, *The German Way of War: From the Thirty Years' War to the Third Reich* (Lawrence, KS: University Press of Kansas, 2005), 267.

armor technology, it codified its WWI experience into a semi-mechanized doctrine of *bataille conduite* (“methodical battle”).¹⁵

The third case study (part III) examines the US Army in the post OIF/OEF environment to determine: first, the specific conditions in the United States following the drawdown of combat forces from Iraq and Afghanistan, second, the decisions, actions, and trends concerning the US Army’s innovation efforts to effectively leverage the full capabilities of emerging autonomous robotic ground weapon systems technology, and third, the likely and potential impacts and consequences on ground combat operations in the 21st century.

Though combined arms doctrine of the Second World War relied heavily upon the developments of combat aircraft, FM radio, mobile artillery, motorized vehicles, dispersed Infantry formations, and tanks, the scope of this study will focus primarily on the tank and armor development as the primary catalyst for innovation. Additionally this study is strictly limited to unclassified robotic weapons systems research and development.

¹⁵ Robert Doughty, *The Seeds of Disaster: The Development of French Army Doctrine 1919-1939* (Hamden, CT: Archon, 1985), 4.

Part I

German Army Case Study 1919 – 1939

The greater the advance of technical science, the more effectively can it devote its inventions and instruments to the service of the army and the higher will be the demands it makes on the soldier who manipulates these technical aids. Anyone who has the smallest idea what technical knowledge, what numerous instruments...must admit that these essential qualities cannot be taken for granted with men whose training had been brief and superficial, and that such men, pitted against a small number of practiced technicians on the other side, are “cannon fodder” in the worst sense of the term.¹⁶

-General Hans Von Seeckt, 1919

When the belligerent nations ceased hostilities after the First World War by signing the armistice in 1918, the German army was severely depleted and its national government quickly experienced a turbulent transition from a monarchy into a republic.¹⁷ Then in 1919, the Treaty of Versailles imposed severe repatriation penalties upon Germany and its stipulations severely restricted the German army's capacity to train or even maintain a defense force much beyond that of a reinforced border guard.¹⁸ Almost immediately, the leadership of the German army determined it was no longer able to meet the strategic policy aims of its national government through the application of military force and set out to identify a solution. Although the explicit terms of the Versailles Treaty served as a forcing function for many of these initiatives, the specific actions taken by the German army during the interwar period 1919 – 1939 are worth examining in closer detail, because they are derived from conditions of defeat, and a perception of crisis. This condition facilitated an environment open to change, and therefore served as a springboard for innovation with emerging technological weapons capabilities of the period.

¹⁶ James Corum, *The Roots of Blitzkrieg: Hans von Seeckt and German Military Reform* (Lawrence, KS: University Press of Kansas, 1992), 33.

¹⁷ Manfred Messerschmidt, “German Military Effectiveness between 1919 and 1939,” in *Military Effectiveness Volume II: The Interwar Period*, ed. Allen Millet, Peter Peret (Boston, MA: Unwin Hyman, 1990), 219-220.

¹⁸ Allen Skinner, “Transformation of the German Reichsheer” (master's thesis, US Army Command and General Staff College, 1992), 5.

This case study focuses primarily on the German Army in the decade immediately following WWI and its methods of developing what would later become known as combined arms maneuver, often referred to by the subsequent colloquial term *blitzkrieg* (“lightning war”).¹⁹ It will examine the development and integration of motorized technology with specific emphasis on armor development, while acknowledging that the tank, airplane, FM radio, automobile, artillery, and dispersed motorized infantry formations were also equally vital components of the German combined arms maneuver doctrine. For the purpose of analysis, the German Army’s experience during the interwar years can be divided into two periods. The first period includes its years as the *Reichswehr* under the authority of the Republic from 1921-1933, and the second period includes its years as the *Wehrmacht* under the authority of the National Socialist regime, from 1933-1945.²⁰

The scope of this case study focuses primarily on the *Reichswehr* period from 1921 – 1933 because these years contain the preponderance of foundational doctrine development.²¹ It does not closely examine German strategic policy, national economic resources, or naval warfare development specific to the period. Air force developments are included only where the research is pertinent to close air support. The three essential components compared and examined in this case study include: first, the specific conditions that existed relative to the German Army, second, the significant decisions and actions taken by the German Army during the *Reichswehr* years to develop its mechanized combined arms doctrine, and third, the consequences of these decisions and actions on *Wehrmacht* tactical operations later executed during the opening months of the Second World War.

The conditions facing the German Army at the conclusion of the First World War were immensely challenging. Defeated on the Western front, it was drastically depleted from fighting four

¹⁹ Robert Citino, *Blitzkrieg to Desert Storm: The Evolution of Operational Warfare* (Lawrence, KS: University Press of Kansas, 2004), 18.

²⁰ Messerschmidt, “German Military Effectiveness between 1919 and 1939,” 218.

²¹ Ibid.

consecutive years during the most destructive conflict Europe had ever experienced. The army sustained the vast preponderance of Germany's 1,835,000 killed in action and 750,000 prisoners of war.²² The German Imperial Army experienced stagnated fighting within the infamous trenches of the Western front in France while it simultaneously fought a mobile-style of warfare along the Eastern front in Russia.²³ While the obligation to fight on multiple fronts enhanced the experience levels of its officers, it placed increased strain on sustainment, which also contributed to its weakened, post-war economic state.²⁴

In addition to combat attrition rates, the Versailles treaty required the army to initiate a substantial reduction of its total number of troops and capped its force level at 100,000.²⁵ The treaty also forbade Germany from developing or maintaining equipment perceived by the international community as necessary to conduct future offensive operations such as heavy artillery, tanks, chemical weapons, or military airplanes.²⁶ During the period required to implement these reforms, the German Imperial Army transformed itself into the structure of what became known as the *Reichswehr*. Once implemented, these measures left the German Army in great danger of becoming an ineffective, hollowed-out force.

As German professional officers analyzed their recent experiences in the First World War, many of the lessons were not yet apparent to them.²⁷ Much of the emerging technology of the period was still in its early stages of development and therefore largely appeared only in the margins, or merely as support platforms or enablers for the mass-wave infantry charges and intense artillery barrages common to the

²² James McRandle and James Quirk, "The Blood Test Revisited: A New Look at German Casualty Counts in World War I," *The Journal of Military History* 70, no. 3 (July, 2006): 688, accessed April 23, 2015, <http://www.jstor.org/stable/4138120>.

²³ Corum, *The Roots of Blitzkrieg*, 7.

²⁴ Ibid.

²⁵ Williamson Murray and Thomas O'Leary, "Military Transformation and Legacy Forces," *Joint Forces Quarterly* (Spring 2002): 21, accessed March 31, 2015, <http://www.dtic.mil/doctrine/jfq/jfq-30.pdf>.

²⁶ Corum, *The Roots of Blitzkrieg*, 34.

²⁷ Murray, "Armored Warfare," 8.

Western front. The German Army in particular did notice the potential effectiveness of the early tank designs at battles such as Cambrai in 1917, and Amiens in 1918.²⁸ During both of these battles, approximately 500 British tanks successfully penetrated the German defensive lines and inflicted heavy losses against the Imperial Army.²⁹ On average, however, most of these early tanks were slow to advance and quick to break down, offering their crews "...minimum vision, maximum discomfort, and general mechanical unreliability."³⁰ In fact, as historian Michael Howard explains, the German Army considered its most successful innovation of the First World War to be its development of storm trooper attacks, dispersed groups of Infantry armed with mortars and light machine guns that could operate independently and penetrate at weak points along the enemy lines.³¹

Given the immense damage and horrific casualties sustained during the First World War, along with the draconian stipulations of the disarmament clause of the Versailles treaty, it is clear that the *Reichswehr* faced substantial fiscal and manpower resource constraints. Its leadership needed to develop creative approaches for implementing innovative solutions in order to achieve more with less. As the Chief of Staff, General Hans Von Seeckt (1866-1936) assumed responsibility for orchestrating this monumental task.³²

General Von Seeckt fought on both the Western and Eastern fronts during WWI and provided key contributions to the breakthrough against Russian forces near Gorlice.³³ He served as Chief of Staff from 1919-1920, and as Army Commander from 1920 – 1926 which meant he was the senior leader of

²⁸ Corum, *The Roots of Blitzkrieg*, 22.

²⁹ Ibid.

³⁰ Murray, "Armored Warfare," 6.

³¹ Michael Howard, *War in European History* (Oxford: Oxford University Press, 2009), 131.

³² Trevor Dupuy, Curt Johnson, and David Bongard, eds., *The Harper Encyclopedia of Military Biography* (New York: Harper Collins, 1992), 670.

³³ Robert Citino, *The German Way of War: From the Thirty Years' War to the Third Reich* (Lawrence, KS: University Press of Kansas, 2005), 242.

the German *Reichswehr* during the early, formative years of its structural and doctrinal reform.³⁴ As Kuhn's theory of scientific revolutions suggests, the emergence of new theories from a crisis require large-scale paradigm shifts following distinct periods of professional insecurities.³⁵ Von Seeckt shrewdly perceived the crisis before him, and focused his efforts toward creating a land force that could absolutely restore decisive maneuver to the European battlefield in order to deliberately avoid another war of attrition like the one which emerged along the Western Front during the First World War.³⁶ He observed that the army nearly exhausted itself by investing tremendous resources into a colossal conflict that proved politically indecisive. The German army possessed a wealth of combat experienced soldiers but the Versailles treaty forced it to dramatically downsize its troop strength and significantly reduce its defense budget, which severely limited its force readiness. For these reasons, von Seeckt perceived the army to be in crisis, and thus became determined to identify a comprehensive solution.

To identify how von Seeckt created this solution, it is useful to closely examine the significant decisions and actions taken by the German Army during the *Reichswehr* years. In this period they leveraged the capabilities of available emerging technology such as the automobile, airplane, tank, and radio, and took steps to develop what would later become its mechanized, combined arms doctrine. Perhaps the paramount action taken by General von Seeckt was to deliberately foster a collaborative climate of technological innovation within the *Reichswehr*. Specifically, he recognized that the status quo of nineteenth-century style warfare, with its massed-wave Infantry assaults were unacceptable because the emergent technology of the era had already degraded this method's effectiveness and he believed it would soon render it obsolete entirely.³⁷ In his 1930 work titled *Thoughts of a Soldier*, von Seeckt wrote...“Perhaps the principal of the levy in mass, in the nation in arms, has outlived its usefulness,

³⁴ Corum, *The Roots of Blitzkrieg*, xii.

³⁵ Kuhn, *The Structure of Scientific Revolutions*, 63.

³⁶ Citino, *The German Way of War*, 242.

³⁷ Corum, *The Roots of Blitzkrieg*, 30

perhaps the *fureur du nombre* has worked itself out. Mass becomes immobile, it cannot maneuver and therefore cannot win victories, it can only crush by sheer weight.”³⁸ Von Seeckt made it a priority to shape the vision of the *Reichswehr* officers beyond mere *schlagworte* (“buzzwords”), and realized the entire maneuver officer corps must be open to paradigm shifts about warfighting and strive to seek innovative ways to incorporate the capabilities of the new *Maschinenwaffen* (“machine weapons”) to restore decisive maneuver to the battlefield.³⁹ For von Seeckt, harnessing the recent combat experience of the junior officer corps and applying it toward this effort remained imperative. He directed the creation of nearly sixty military inspectorates and committees to conduct comprehensive reviews of the lessons of the Imperial Army in WWI.⁴⁰ Additionally, he deliberately selected nearly 400 of the most capable and combat experienced officers to diligently perform this task.⁴¹ In this way, von Seeckt ensured that the primary contributors to these reviews and subsequent doctrinal development were not simply the product of a handful of officers assigned to an isolated bureaucratic cell, but instead accurately captured the energetic feedback of the experienced junior officer corps.

General von Seeckt sharply raised the professional academic standards for *Reichswehr* officers and ensured official maneuver course curriculums directly addressed the latest advancements in emergent technology.⁴² He required senior officers to attend bi-monthly technology seminars covering the topic of weapons, armored cars, tanks, and motor vehicle transport.⁴³ Even though the stipulations of the Versailles Treaty explicitly forbade the *Reichswehr* from developing, manufacturing, or fielding offensive

³⁸ Corum, *The Roots of Blitzkrieg*, 30

³⁹ Citino, *The German Way of War*, 240-241.

⁴⁰ Williamson Murray, “Innovation: Past and Future,” *Joint Forces Quarterly* (Summer 1996): 43.

⁴¹ Corum, *The Roots of Blitzkrieg*, 37.

⁴² *Ibid.*, 83.

⁴³ *Ibid.*, 101.

weapon systems such as tanks, von Seeckt insisted his subordinate officers dedicate much of their personal time and attention to state-of-the-art advancements in both civilian and military technology, and embraced the notion *die Gedanken sind frei* (“thoughts are free”).⁴⁴ This fostered a culture within the army open to capturing bottom-up ideas and theories of how to efficiently integrate emerging commercial and military technology such as the tank airplane, automobile, and radio system into its future maneuver doctrine.

Reichswehr officers were highly encouraged to volunteer for ninety-day assignments abroad to study armor development in foreign countries and to provide published reports upon their return to Germany.⁴⁵ Despite the fact that the *Reichswehr* did not yet field any tanks, General von Seeckt required every subordinate command to designate an Officer to serve as the unit’s subject matter expert on armor technology, and to be directly responsible for training the rest of the unit on tank development.⁴⁶

The deliberate, collaborative, professional environment that von Seeckt promoted within the *Reichswehr* resulted in the creation of Army Regulation 487 (Leadership and Battle with Combined Arms) published in 1921, with a second volume published in 1923.⁴⁷ This doctrinal publication encompassed the results of many of the initiatives directed by von Seeckt and served as the base foundation for the subsequent development of Panzer Divisions and Corps throughout the 1930s.⁴⁸

After publishing the Army Regulation 487, the *Reichswehr* still needed to train and equip its force while maintaining a keen eye on concurrent developments in emergent technology. One example is the invention of the Enigma code machine by civilian Arthur Schertius in 1923, which the *Reichswehr*

⁴⁴ Robert Citino, “‘Die Gedanken Sind Frei’: The Intellectual Culture of the Interwar German Army,” *The Army Doctrine and Training Bulletin* 4, no. 3 (Fall, 2001): 48.

⁴⁵ Skinner, “Transformation of the German Reichsheer,” 51.

⁴⁶ Corum, *The Roots of Blitzkrieg*, 132.

⁴⁷ *Ibid.*, 39.

⁴⁸ *Ibid.*, 202.

quickly adapted for military use.⁴⁹ Although the Versailles treaty explicitly forbade Germany from developing or maintaining tanks, the *Reichswehr* leadership mandated deliberate representation of tanks and air planes into all of their wargame exercises, so its fledgling combined arms doctrine could be sufficiently tested and practiced.⁵⁰ Examples of their use of simulated tanks can be found in the 1928 maneuvers in Silesia, where they were utilized to effectively overrun a division headquarters.⁵¹ During the fall maneuvers of 1930, the *Reichswehr* again conducted their training exercises using simulated tanks under headquarters units representing a force of over ten divisions, the largest German maneuver force assembled since 1919.⁵²

One key aspect of these simulations was the full integration of FM radio communications technology. The *Reichswehr* realized the critical importance of FM Radio communications and its role in enabling direct voice commands to control mobile formations during these exercises. They applied radio technology in such a way as to achieve more than just a redundant form of communications between defensive unit headquarters posts. As historian Robert Citino reveals, “Although all Western nations shared the technology of radio, it was the Germans who put it through the most far-reaching tests...” For example, in 1932, the *funkübung* (“radio exercise”) employed over 300 officers, 2000 Soldiers, and 400 motor vehicles to provide command and control of simulated operational maneuvers via FM radio communications.⁵³ During the interwar years, Germany shrewdly devised several methods to bypass restrictions of the Versailles treaty, such as secret collaboration with the Soviet Union on airplane and tank research and the establishment of the Russian/German tank center at Kazan.⁵⁴ However, the

⁴⁹ Corum, *The Roots of Blitzkrieg*, 108.

⁵⁰ Citino, *Blitzkrieg to Desert Storm*, 19.

⁵¹ Citino, *The German Way of War*, 255.

⁵² *Ibid.*, 249.

⁵³ Citino, *Blitzkrieg to Desert Storm*, 23.

⁵⁴ Corum, *The Roots of Blitzkrieg*, 98.

Reichswehr did not have an actual tank available for participation in its major field maneuver exercises until 1935, nearly fourteen years after Army Regulation 487 had been originally been published.⁵⁵

Under the direction of General Hans von Seeckt, the doctrine produced by the *Reichswehr* in the early 1920s served as a foundational concept that the German Army continued to build upon throughout the subsequent years of the interwar period, which eventually expanded into the development of the Panzer Divisions and Corps.⁵⁶ This expansion coincided with the aggressive rearmament policies of the National Socialists during the late 1930s, which enabled the *Wehrmacht* to rapidly grow and equip its early mechanized force.⁵⁷

After subsequently refining the doctrine that would later become known as *blitzkrieg* during the invasion of Poland, the German army invaded France in May of 1940.⁵⁸ At the time of this invasion, only a very small percentage (10%) of German forces were mechanized.⁵⁹ In 1940 the German Army still possessed more horses than motor vehicles, at nearly a five to one ratio; however the doctrinal innovations rooted in the 1920s facilitated the successful employment and tactical maneuver of this mechanized technology into air and ground combat operations.⁶⁰ The German spearhead of armored columns reached the French coast in less than one week, and France formally surrendered before the end of June, 1940.⁶¹ The result of the *Reichswehr's* innovation was the development of a successful

⁵⁵ Citino, *The German Way of War*, 255.

⁵⁶ Corum, *The Roots of Blitzkrieg*, 202.

⁵⁷ Ibid., 200.

⁵⁸ Doughty, *The Seeds of Disaster*, 4.

⁵⁹ Peter W. Singer, *Wired for War: The Robotics Revolution and Conflict in the 21st Century* (New York: Penguin, 2009), 429.

⁶⁰ Alistair Horne, *To Lose a Battle: France 1940* (New York: Penguin, 1990), 229.

⁶¹ Doughty, *The Seeds of Disaster*, 1.

combined arms doctrine that fully harnessed the integrated capabilities of emergent technology of the period and set the paradigm for mechanized warfare in the 20th century⁶².

The battle along the Meuse River in 1940 and the subsequent breakthrough of the German Panzer formations to the English Channel serve as one of the most notable examples of decisive victory in modern military history. Although the battle itself contained due aspects of friction and chance, the steps taken by the German *Reichswehr* during the interwar years provide a useful model of military doctrine development because it required an innovative application and adaption of new technological capabilities of the period. This case study reveals that the technological platforms themselves are perhaps less critical than the specific imaginative approach taken to apply the new technology in battle. The preponderance of technology used to develop the doctrine of combined arms maneuver was a direct result of the exploitation of that available and emerging for commercial utilization during the interwar period and subsequently adapted for military use. Examples include the combustible engine, automobile, tractor, armored car, airplanes, and FM radio system.

The leadership of the German army perceived the organization to be in crisis because it knew it could not win a future war of attrition. As Thomas Kuhn's theory suggests, this perception of crisis seems to have been the critical factor that drove the need for innovation. The army created conditions necessary to effectively harness the intellect and combat experience of the junior officer corps and to earnestly explore possibilities rendered achievable by the emergent technology of the period. This perception of crisis enhanced the army's willingness to cognitively transcend the paradigm(s) of the 1918 western front by innovating with newly available technological concepts to restore a method of decisive maneuver to the battlefield.⁶³ The *Reichswehr* recognized that an attrition strategy was a critical vulnerability, and developed a doctrine to mitigate it. Despite their lack of financial and equipment

⁶² Michael Geyer, "German Strategy in the Age of Machine Warfare," in *Makers of Modern Strategy: from Machiavelli to the Nuclear Age*, ed. Peter Paret (Princeton, NJ: Princeton University Press, 1986), 543.

⁶³ Kuhn, *The Structure of Scientific Revolutions*, 63.

resources, the German Army successfully tested their theoretical doctrine by using simulated equipment during its field training exercises, and by deliberately increasing the technical education and awareness of its officer corps.⁶⁴

The above case study serves as a model of successful innovation, because it facilitated a tremendous tactical and operational advantage during the opening months of the Second World War, which decisively set the conditions required to achieve strategic victory for its civilian policy makers.

⁶⁴ Alistair Horne, *To Lose a Battle: France 1940* (New York: Penguin, 1990), 88.

Part II

French Army Case Study 1919 – 1939

In the final analysis, the French High Command lacked a clear chain of authority and responsibility that could provide the army a firm sense of direction for developing its doctrine and designing its weapons. While over-centralization may stifle initiative, the fragmented organization of the French High Command also stifled creative solutions to doctrinal problems.⁶⁵

-Robert Doughty, 1985

After Marshal Foch received the German signature on the armistice in November, 1918, the French Army was considered by many to be the premier military land power in the western world.⁶⁶ After persevering through four intense years of devastating conflict on French soil, and after sustaining immense numbers of casualties the alliance finally defeated the juggernaut of the German Imperial Army. Over the following two decades, the French Army anticipated the possibility of another war with Germany with considerable trepidation.⁶⁷ Unlike the *Reichswehr*, at the start of the interwar period, the French Army did not perceive itself to be in crisis, and therefore was not as determined to innovate with the new capabilities offered by emergent technology. Although they continued to research and develop more advanced tanks, the French largely used their technologically superior weapons systems to augment and enhance their existing doctrinal approach, which favored firepower and the defensive.⁶⁸

The French Army, in the decade immediately following WWI expanded upon its doctrine of *bataille conduite* (“methodical battle”).⁶⁹ It also examined developments of the mechanized technology with specific emphasis on armor development, and acknowledged the tank, airplane, FM radio, automobile, light machine gun, mortar, artillery cannons, and infantry rifles. Each of these areas

⁶⁵ Doughty, *The Seeds of Disaster*, 128.

⁶⁶ Ibid., 1.

⁶⁷ Ibid., 5.

⁶⁸ Ibid.

⁶⁹ Ibid., 3-4.

witnessed technological advancements and upgrades in France during the interwar period. Similar to the German Army, the French Army's experience during the interwar years can also be divided into two periods for the purposes of analysis. The first includes the years that Marshal Petain served as Superior Council of War 1920 – 1931 and the second period includes its years with General Gamelin as Chief of the General Staff 1935 – 1940.⁷⁰

Each contributed to various aspects of the French Army's defeat in 1940. France's strategic policy, national economic resources, and naval warfare development specific to the period are not closely examined. Air force developments are included only where the research is pertinent to close air support. Three essential components examined in this case study include: first, the specific conditions that existed relative to the French Army, second, the significant decisions and actions taken by the French Army to develop its methodical battle doctrine, and third, the consequences of these decisions and actions on tactical operations during the opening months of the Second World War.

The conditions facing the French Army at the conclusion of the First World War were not as dire as those facing the German Army, however there are distinct parallels between the two. The French sustained nearly 1.4 million killed or missing in action during the war which impacted its very identity, and shaped its paradigm about future operations.⁷¹ Unlike the German Imperial Army, the French Army fought almost exclusively along the Western Front, and their subsequent doctrine was largely shaped by their experiences with intense artillery barrages synonymous with stale-mated, trench warfare.⁷² This helped reinforce a nearly impregnable cognitive paradigm among its senior officers that systematic

⁷⁰ Doughty, *The Seeds of Disaster*, 112.

⁷¹ Ibid., 72.

⁷² Corum, *The Roots of Blitzkrieg*, 7.

firepower was paramount in order to set the conditions for counter-attack maneuver.⁷³ For many years, French army officers adhered to Marshal Petain's reminder, *Le fue tue* ("firepower kills").⁷⁴

Like the *Reichswehr*, as French professional officers analyzed their recent experiences in the First World War, however, many of the lessons were not yet apparent to them. Much of the emerging technology of the period such as the tank and airplane were still in their early stages of development and therefore appeared in the margins, or merely as support platforms or enablers for the ubiquitous, mass-wave infantry charges designed to leverage the spirit of *elan* and concentrated artillery barrages to achieve a breakthrough along the Western Front.⁷⁵ During the interwar years, French officers studied the August, 1918 Battle of Montdidier as the defining example of its methodical battle doctrine.⁷⁶ During this specific operation, the entire First French Army utilized coordinated artillery barrages to set the conditions for an enormous infantry flanking maneuver behind German lines, and provided the model for how future counter-attacks would be executed against an opposing enemy force.⁷⁷

Like the *Reichswehr*, the French Army found itself in a fiscally strained environment following the war, though not nearly as severe, but the sharp reductions to the national defense budget resulted more from consensus among national policy makers in Paris, and were also influenced by the requirement to provide forces to secure overseas colonies such as Algeria.⁷⁸ By 1920, the French Army was reduced to thirty-two active divisions, and six years later it was again reduced to just twenty active divisions.⁷⁹ Although the French Army petitioned for an active-force end strength of 150,000 the government

⁷³ Bond and Martin, "Liddell Hart and DeGaulle," 604.

⁷⁴ Ibid.

⁷⁵ Murray, "Armored Warfare," 30.

⁷⁶ Doughty, *The Seeds of Disaster*, 81.

⁷⁷ Ibid., 80.

⁷⁸ Ibid., 19.

⁷⁹ Ibid.

mandated its force cap at just 106,000.⁸⁰ As in the previous case study, French military planners were challenged to develop innovative ways to achieve more with less. Perhaps the two military officers most responsible for meeting this challenge were Marshal Philippe Petain (1856-1951) and General Maurice Gamelin (1872-1958).⁸¹

Marshal Petain served as vice president of the Superior Council of War, 1931-1935, General Debeney served as Chief of the General Staff 1920 – 1930, and General Gamelin also served as Chief of the General Staff, 1931 – 1940.⁸² Here, there is a distinct divergence in models between the French and German cases. While General Hans von Seeckt held unified control over the *Reichswehr*, and experienced little opposition or interference from the fledgling civilian government in Berlin, the French Army's command structure was intentionally diffused by the established civilian government in Paris in order to limit military authority in France, which therefore increased the complexity of its administrative apparatus and hierarchy.⁸³ Similarly, as the treaty of Versailles virtually eliminated the German Army's offensive weapons inventory, their officers were relatively free to develop their doctrine from the ground up.⁸⁴ In contrast, the French Army maintained a significant amount of its war material from WWI, such as the Renault light tank, and any French doctrine would naturally be biased to conform to existing equipment in its inventory.⁸⁵

As Thomas Kuhn's theory of scientific revolutions suggests, the French Army, under Marshal Petain did not perceive a crisis before it, and concentrated its efforts toward creating a land force that

⁸⁰ Doughty, *The Seeds of Disaster*, 19.

⁸¹ Trevor Dupuy, Curt Johnson, and David Bongard, eds., *The Harper Encyclopedia of Military Biography* (New York: Harper Collins, 1992), 273,588.

⁸² Doughty, *The Seeds of Disaster*, 112.

⁸³ *Ibid.*, 116.

⁸⁴ Corum, *The Roots of Blitzkrieg*, 99.

⁸⁵ *Ibid.*

could defeat its adversaries as deliberately as they had done at the battle of Montdidier 1918.⁸⁶ By leveraging elaborately prepared defensive positions, and using the centrally controlled, methodical, application of immense volumes of firepower, the French leadership believed it could stop aggressors and set the conditions for successful counter attack.⁸⁷ In this respect, the French army prepared itself to fight its future wars using the very same methods of old science that it believed made them successful during its previous war.

An analysis of the specific conditions that existed relative to the French army immediately following WWI reveal that the army had sustained nearly 1.4 million casualties and it attributed the preponderance of these casualties to an over-reliance on the offensive. The army lost much of its combat experience as national policy makers chose to rapidly downsize the force. As with Germany, France also sharply reduced its defense budget, which inherently degraded force readiness. Emerging technology of the period such as the automobile, airplane, and radio continued to rapidly thrive and advance due to increased commercial applications and demand.

Many of the significant actions and decisions taken by the French Army during the interwar years are comparable and contrastable with those of the *Reichswehr*. Perhaps one of the most obvious distinctions between the French and German cases, is the French Army's lack of encouragement for collaboration and imaginative innovation among its junior officer corps. Professional recommendations for possible adaptations or evolutions of French doctrine were strongly discouraged and quickly dismissed. One historical account suggests that the French officer corps started exploring these avenues with vigor, but were gradually stifled by staunch institutional paradigms and ubiquitous force reduction initiatives:

The conference chambers of the Ecole de Guerre and the training grounds of Coetquidan Mailly, and Mourmelin were alive in the 1920s to the sound of the theory and practice of mobile experimentation. As the decade wore on, however, stultification replaced innovation.

⁸⁶ Doughty, *The Seeds of Disaster*, 83.

⁸⁷ Corum, *The Roots of Blitzkrieg*, 49.

Experimentation diminished as technologically advanced and thus costly activities fell prey to the reductions in military budgets that went with the postwar climate of peace.⁸⁸

This evidence serves to reinforce the observation that meaningful innovation incentives were neither present nor encouraged within the ranks of the French officer corps during the interwar period.

Further, although the French Army continued to conduct research and development for more advanced tanks and weaponry, the senior leadership of the French Army did not seem to welcome debate amongst officers concerning their mechanized doctrine.⁸⁹ Additionally, while the *Reichswehr* doctrine promoted tactical initiative by subordinate commanders, French doctrine increasingly relied on centralized authority with rigid tactical command and control.⁹⁰ In 1921, Marshal Petain presided over a commission of just thirteen officers to produce the French Army's capstone doctrine, *Provisional Instructions on the Tactical Employment of Large Units*.⁹¹ This doctrine essentially captured the paradigm of 1918 and cemented it as the vision of the French army for the next decade.⁹²

One of the results of the French Army's doctrine was its specific vision for employment of advancing technology, such as the tank, airplane, and radio. Although their research and development efforts appreciated the importance of tanks throughout the interwar period, they continued to employ them within their paradigm of 1918. Adherence to this outdated paradigm contributed in part to the development of a French force that possessed technologically superior tanks, but did not defeat the German invasion in 1940.⁹³ Although it offered spirited resistance, the French Army had poor tactical

⁸⁸ Bond and Martin, "Liddell Hart and DeGaulle," 604.

⁸⁹ Murray, "Armored Warfare," 47.

⁹⁰ Bond and Martin, 604.

⁹¹ Doughty, *The Seeds of Disaster*, 9.

⁹² Ibid.

⁹³ John Mosier, *The Blitzkrieg Myth: How Hitler and the Allies Misread the Strategic Realities of World War II* (New York, NY: Perennial, Harper Collins, 2004), 43-44.

intelligence and extremely degraded command and control.⁹⁴ Their rigid doctrine was designed to leverage a short-term conscription force and elaborate fixed site fortifications in order to defeat a German invasion attack, to set the conditions for counterattack.⁹⁵ The thinly arrayed series of fortifications along the Maginot Line, (though never penetrated by German attack), ultimately proved to be an insufficient apparatus for French national defense.⁹⁶ The German Army assumed considerable risk, and sustained over 27, 000 KIA over the course of its invasion of France.⁹⁷ However, once the German *Wehrmacht* crossed the Meuse River, the French Army simply could not adapt to keep up with the rapid pace of the tactical advances. Paris formally surrendered less than sixty days later.⁹⁸

The evidence indicates that the leadership of the French army did not perceive the organization to be in crisis during the interwar period. It believed a future war of attrition might be best fought to victory by relying on fixed defensive positions and superior firepower. As Kuhn's theory suggests, this lack of perceived crisis appears to be the critical factor responsible for stifling potential innovation. The French Army provides an example of an un-successful military innovation model. One that did not achieve an innovative application of new capabilities provided by advancements in the technology of the period. Instead, its technological capabilities were used to augment a pre-existing paradigm. The preponderance of emergent technology available to develop mechanized warfare doctrine was already available due to progress in commercial industries during the interwar period. The French Army's reliance on methodical battle paradigm of 1918 proved to be a failed method because it facilitated a tremendous tactical and operational disadvantage during the opening months of the Second World War. As a result, it inadvertently facilitated conditions for catastrophic strategic defeat for its civilian policy makers.

⁹⁴ Horne, *To Lose a Battle*, 244.

⁹⁵ Citino, *The Roots of Blitzkrieg*, 190.

⁹⁶ Murray, "Armored Warfare," 14.

⁹⁷ Horne, *To Lose a Battle*, 666.

⁹⁸ Doughty, *The Seeds of Disaster*, 1.

Part III

US Army Integration of Robotic Technology on the Battlefield 2005 - 2025

And that's the edge we have to protect, especially in the face of declining budgets and increasing dynamism in the international security environment...And while we have achieved a degree of certainty in our budget for the next two years, we still don't yet have the full flexibility we need to rebalance the force for the challenges that we see ahead. We'll buy back some readiness in the near term and we'll overt a short-term crisis, but we still need to address the long term pressures.⁹⁹

-General Martin E. Dempsey, 2014

As noted in the introduction, evidence exists to support the observation that conditions in 1919 resemble those of 2015 in three primary respects. First, both periods are characterized by a post war environment and a public aversion to the risk of combat casualties. Consequently, both periods shared a common domestic reluctance toward the deployment of ground combat forces abroad. Second, military planners during both periods debated the specific nature of the warfare in the immediate decades and explored methods to achieve more with less. And third, both periods experienced an escalation of emergent and disruptive technological advancement.¹⁰⁰

In both the German and French cases, the development of the tank served as the primary focus for examining technical innovation and development of mechanized warfare doctrine. The research supported the conclusion that the German Army was successful in its approach toward innovation by incorporating the full capabilities of emergent technology while the French Army chose instead to insert the weaponized variants of these commercial technologies into their pre-existing paradigm. Thomas

⁹⁹ "Gen. Dempsey's Remarks at the National Defense University," Joint Chiefs of Staff - Media – Speeches, January 14, 2014, accessed March 26, 2015, <http://www.jcs.mil/Media/Speeches/tabid/3890/Article/571921/gen-dempseys-remarks-at-the-national-defense-university.aspx>.

¹⁰⁰ Joseph L. Bower and Clayton M. Christensen, "Disruptive Technologies: Catching the Wave," *Harvard Business Review* (January 1, 1995): 1, accessed April 2, 2015, <https://hbr.org/1995/01/disruptive-technologies-catching-the-wave>.

Kuhn's theory suggests that the disparity in innovation can be attributed directly to the fact that following the First World War, the German Army perceived itself in crisis, and the French Army did not.

This third case study examines the US Army within the contemporary post-war environment, and its readiness initiatives toward Force 2025. Specifically, it examines the US Army's approach toward development and employment of autonomous ground robotic weapon systems in respect to doctrinal innovation. Further, it compares specific conditions, significant actions, and results.

In 2014, as a result of reductions to the defense budget, the US Army reduced its active force by five Brigade Combat Teams (BCTs), and is currently on track to eliminate another six BCTs during 2015.¹⁰¹ The plan is expected to reduce the overall active force strength from 520,000 to less than 450,000 and from 44 BCTs to just 28 BCTs by FY 2019.¹⁰² These reductions place the Army's end strength at its lowest level since before the Second World War.¹⁰³ Additionally, the Army's Overseas Contingency Operations (OCO) budget for FY15 was only 28 Billion dollars, which is nearly a 77% reduction from the FY07 budget, and the lowest OCO budget level since FY03.¹⁰⁴ Senior Pentagon officials have articulated the risk associated with these spending cuts given myriad uncertainty of global force commitments in Syria, Iraq, Yemen, Ukraine, Africa, and others.¹⁰⁵ At a recent Pentagon posture hearing, Army Chief of

¹⁰¹ Ben Watson, "Three Years After Leaving Iraq, the Army Is Officially Back," Defense One, accessed March 26, 2015, <http://www.defenseone.com/feature/state-of-defense-2015/>.

¹⁰² Matthew Cox, "Army Must Shed 6 BCTs to Meet Proposed Budget Cuts," Military.com News, February 28, 2014, accessed March 31, 2015, <http://www.military.com/daily-news/2014/02/28/army-must-shed-6-bcts-to-meet-proposed-budget-cuts.html>.

¹⁰³ Nick Simeone, "Hagel Outlines Budget Reducing Troop Strength, Force Structure," US Department of Defense News, February 24, 2014, accessed March 26, 2015, <http://www.defense.gov/news/newsarticle.aspx?id=121703>.

¹⁰⁴ Ben Watson, "Three Years After Leaving Iraq, the Army Is Officially Back," Defense One, accessed March 26, 2015, <http://www.defenseone.com/feature/state-of-defense-2015/>.

¹⁰⁵ Ibid.

Staff, General Raymond Odierno stated “We are back in Iraq. Here we are worried about Russia again. So I think we should be very careful and mindful of the decisions we are making.”¹⁰⁶

During a recent interview at the 2014 Aspen Security Forum, Chairman of the Joint Chiefs of Staff, General Martin Dempsey explained the potential impacts that sequestration driven cuts may have on readiness. “We have never in my history -- I’m 40 years in the Army, by the way -- we have never, ever had a point in my 40 years in the military where someone would say, go do this and where I could say, OK, I’ll do it, but if I go over there, I can’t be over here. Never happened. We’re approaching that point right now.”¹⁰⁷ In January, 2015 Secretary of Defense Chuck Hagel spoke with serviceman stationed at Whiteman, AFB and conveyed his reservations about expanding the use of ground forces in Syria and Iraq, “We’re effected by that. The answer is not for us to continue to send troops to fight other people’s wars.”¹⁰⁸ In this respect, the US Army faces many similar challenges as the interwar French and German Armies concerning force cuts and reduced federal defense spending.

One primary reason for the US Army’s force reduction is the large manpower costs associated with supporting and sustaining its Soldiers. According to the Congressional Budget Office, the Department of Defense requested nearly \$150 billion to fund the pay and benefits of active and retired service members, which exceeded more than one quarter of the entire DoD budget request for FY13.¹⁰⁹ Measured in 2013 dollars, the DoD annual health care costs alone are projected to increase by \$14 billion

¹⁰⁶ Ben Watson, “Three Years After Leaving Iraq, the Army Is Officially Back,”

¹⁰⁷ “Gen. Dempsey Remarks at the Aspen Security Forum 2014,” Joint Chiefs of Staff - Media – speeches, July 14, 2014, accessed March 26, 2015, <http://www.jcs.mil/Media/Speeches/tabid/3890/Article/571964/gen-dempsey-remarks-at-the-aspen-security-forum-2014.aspx>.

¹⁰⁸ “Remarks by Secretary Hagel at a Troop Event at Whiteman Air Force Base, Missouri,” US Department of Defense - News - Transcripts, January 13, 2015, accessed March 26, 2015, <http://www.defense.gov/Transcripts/Transcript.aspx?TranscriptID=5564>.

¹⁰⁹ *CBO Costs of Military Pay and Benefits in the Defense Budget* (Washington D.C.: US Congressional Budget Office, 2012), 3, accessed March 26, 2015, http://www.cbo.gov/sites/default/files/11-14-12-MilitaryComp_0.pdf.

within four years (2013-2017), and are expected to increase again up to nearly \$77 billion dollars per year, by 2022.¹¹⁰ In the contemporary post war environment, given that the costs of sustaining the force are projected to increase while the force size is projected to decrease, planners are faced with the challenge of doing more with less. During the interwar period, components of commercial driven technology such as the combustible engine offered the French and German Armies an available means to supersede the paradigm of 1918 and restore maneuver to the European battlefield. Similarly, one potential option for the US Army is to leverage the increasing capabilities of autonomous robotic systems in order to meet the challenges of the uncertain nature of warfare in the decades ahead.

During the interwar period, commercial demand drove advancements in the airplane, radio, and automobile designs available to the French and German Armies. Similarly, in the post OEF/OIF environment, commercial demand has driven significant advancements in robotics and artificial intelligence technology available to the US Army. Ray Kurzweil's "Law of Accelerating Returns" explains the phenomenon by describing how the rate of progress of a given evolutionary process exponentially increases over time.¹¹¹ Therefore, as much of the mechanized weapons technology of 1918 quickly became obsolete by the 1930s, much of the robotic weapons technology used in OEF/OIF will likely be obsolete in the US Army by 2025. However, the US Army does not presently appear to fully anticipate a need to incorporate autonomous robotics into doctrine or collective training exercises. Therefore, the US Army's approach with robotics mirrors the French Army's approach with armor during the interwar period because collective training events strictly adhere to the existing equipment already in the inventory.

As the German case study revealed, the *Reichswehr* insisted its officers closely follow the latest technological advancements and consider potential adaptations to battlefield use. There is currently no

¹¹⁰ *CBO Costs of Military Pay and Benefits in the Defense Budget*, 3.

¹¹¹ Ray Kurzweil, "The Law of Accelerating Returns," Kurzweil Accelerating Intelligence, March 7, 2001, accessed March 29, 2015, <http://www.kurzweilai.net/the-law-of-accelerating-returns>.

formal emphasis or expectation for US Army officers to remain closely attuned to emerging technology in the civilian sector. In this aspect, the US Army is presently more closely aligned with the interwar French Army.

The decreasing costs and commercial proliferation of these robotic systems has eliminated state government monopoly on the research and development of these semi-autonomous and autonomous robotic systems. They are widely available to the international community as well as to non-state actors, and at the time of this writing, there are 76 countries with known military robotic weapons programs.¹¹² For example, in 2013, Russian defense minister Sergei Shoygu announced Russia's planned investment of nearly \$2.4 billion over 24 months for robotic research.¹¹³ One unclassified system designated the MRK-57 "Wolf" is essentially a tracked-armored vehicle with integrated machine guns and laser range finders.¹¹⁴ The specific details of its autonomous robotic features are not yet clear, but this example shows one state actor exploring an armed robotic tactical ground force capability.¹¹⁵ Many of these and similar platforms are designed by engineers, based at the Central Research Institute of Robotics and Technical Cybernetics (RTC) in St. Petersburg, Russia.¹¹⁶

¹¹² Jonathan Marcus, "Robot Warriors: Lethal Machines Coming of Age," BBC News, March 4, 2013, accessed March 29, 2015, <http://www.bbc.com/news/magazine-21576376?print=true>.

¹¹³ Steven Kotler, "Say Hello to Comrade Terminator: Russia's Army of Killer Robots," *Entrepreneurs* (blog), *Forbes*, June 12, 2014, accessed March 29, 2015, <http://www.forbes.com/sites/stevenkotler/2014/06/12/say-hello-to-comrade-terminator-russias-army-of-killer-robots/>.

¹¹⁴ David Hambling, "Russia Wants Autonomous Fighting Robots, and Lots of Them: Putin's Military Is Busy Building Autonomous Tanks with Mounted Machine Guns and Unmanned, Amphibious Jeep-Size Vehicles.," *Popular Mechanics*, May 12, 2014, accessed March 29, 2015, <http://www.popularmechanics.com/military/a10511/russia-wants-autonomous-fighting-robots-and-lots-of-them-16787165/>.

¹¹⁵ Ibid.

¹¹⁶ Andrei Kislyakov "Russia Prepares to Robot Warfare," *Russia Beyond the Headlines*, January 4, 2013, accessed March 29, 2015, http://rbth.com/articles/2013/01/04/russia_prepares_to_robot_warfare_20995.html.

Again, the previous case study revealed how *Reichswehr* officers were highly encouraged to travel abroad to observe how other nations were experimenting with armor and mechanized technology in their respective militaries. There is no such emphasis for US Army officers to pay attention to robotic innovations, and consequently such advanced applications are often dismissed as novelties. In this respect, the US Army's current approach resembles that of the French Army's approach toward FM radio technology during the interwar years. Just as the automobile, airplane and radio continued to advance during the early interwar period, autonomous robotic systems will likely continue to advance during the next decade.

For instance, researchers at Harvard University have recently unveiled the first successful synchronization of a robotic swarm comprised of over 1,000 tiny robots.¹¹⁷ These robot tests set the conditions for more advanced robotic swarms and according to the project director, "In nature, you see examples of millions of army ants working together...We're interested in working toward that goal with robots".¹¹⁸ Many of these flying robots operate at extremely low altitudes and demonstrate the ability to enter and exit buildings, which hold obvious direct impacts for ground maneuver forces. Additionally, both air and ground systems contain software with increasingly sophisticated autonomous decision making ability. For US Army maneuver officers, a potential consequence of so many digital, autonomous robotic systems operating within the same operational environment, and in conjunction with myriad mobile sensors and integrated weapon systems, is that the pace of tactical operations may actually exceed the human mind's capacity to orient, act, and react against enemy threats. Tactical leaders may not be able to keep pace with these increased operating speeds by attempting to employ the robotic weapon

¹¹⁷ Charles Q. Choi, "This Thousand-Bot Swarm Is the Future of Robotics: The Kilobots-a Group of 1,024 Tiny Machines That Can Form Into Complex Shapes-are the Largest Robotic Swarm Ever Created.," *Popular Mechanics*, August 14, 2014, accessed March 29, 2015, <http://www.popularmechanics.com/technology/robots/a11109/this-thousand-bot-swarm-is-the-future-of-robotics-17094774/>.

¹¹⁸ *Ibid.*

systems via the paradigm of remote control. This is congruent with the aspect of interwar French Army doctrine that promoted strict adherence to top-down control over tactical maneuver.

In 1918, weapon systems such as machine gun, artillery, and poison gas contributed to escalated combat casualties at an unprecedented scale. Both the German and French Armies recognized the value of mechanized and armored technology to mitigate these hazards. Similarly, the confluence of DEWs advanced computer systems, electronic sensors, and have the potential to render the tactical environment increasingly hazardous for human combatants, particularly given the principals of Kurzweil's and Moore's law. The US Army has recognized the value of robotic technology to mitigate these hazards, but has not yet clearly identified an innovative approach to fully harness autonomous capabilities. Again, the present approach is congruent with the French Army. The US DoD has made strides in the development of directed energy weapons technology, including the High Energy Liquid Laser Area Defense System (HELLADS). Similarly, in 2013 at the White Sands Missile Range, NM the US Army successfully tested Boeing's HEMTT mounted High Energy Laser Technology Demonstrator (HEL-TD) which utilized lasers to destroy sixty-nine inbound mortar rounds and three airborne UAV targets during its trials.¹¹⁹

This evidence indicates the US Army (and DoD) are actively pursuing advanced weapon systems, but the preponderance of its maneuver officers are not actively contemplating how to employ these capabilities in a comprehensive manner that leverages the full capabilities of DEWs and autonomous robotic systems. The current US Army approach does not parallel the successful *Reichswehr* model, and more closely resembles the French Army model. One existing DEW that demonstrates an institutional paradigm's impact on tactical innovation is Raytheon's ground based, Active Denial System (ADS).¹²⁰ The weapon is designed for non-lethal effects and utilizes an energy beam capable of heating human skin

¹¹⁹ John Cummings, "Directed Energy Symposium Focuses On Solutions to Threats," The Redstone Rocket, March 19, 2014, accessed March 29, 2015, http://www.theredstonerocket.com/tech_today/article_4d2d6e76-af6b-11e3-b695-001a4bcf887a.html.

¹²⁰ "Active Denial System FAQs," Non Lethal Weapons Program U.S. Department of Defense, accessed March 29, 2015, <http://jnlwp.defense.gov/About/FrequentlyAskedQuestions/ActiveDenialSystemFAQs.aspx>.

to 130 degrees Fahrenheit in approximately 2 seconds, with a confirmed operational range of approximately 1,000 meters.¹²¹ Although the DoD had already completed Capabilities and Limitations Assessment (CLA) test of this weapon system in 2008, and approved it for fielding, US Army forces deployed to OEF and OIF were not authorized to utilize their ADS during tactical ground operations due to overarching policy concerns.¹²²

As Kurzweil's Law suggests, DEWs technology will continue to advance globally. In fact, in March, 2015, Lockheed Martin announced the successful testing of its ground-based Advanced Test High Energy Asset (ATHENA), which utilized an invisible laser beam to destroy an operational vehicle engine from a range of over 1 mile.¹²³ The advancements of these weapon systems provide an indication that robotic weapon systems may become increasingly necessary to mitigate the hazardous effects of DEWs on human combatants across the OE within the next decades. According to a program officer at the Office of Naval Research, "The solid-state laser is a big step forward to revolutionizing modern warfare with directed energy, just as gunpowder did in the era of knives and swords."¹²⁴

Two existing robotic systems that may have the most immediate impact for US ground maneuver forces include the LS3 "Alpha-Dog" Legged Squad Support System, which is a robotic quadruped (mule) that can assist dismounted squads by autonomously transporting over 400 pounds of weight or gear across

¹²¹ Colin Clark, "Raytheon Non-Lethal Heat Beam Tackles New Missions," *Breaking Defense*, November 5, 2013, accessed March 29, 2015, <http://breakingdefense.com/2013/11/raytheon-non-lethal-heat-beam-tackles-new-missions/>.

¹²² Richard Lardner, "Energy Beam Weapon Could Be Used in Iraq: But Officials Refuse Concerned That Non Lethal Effects Could Be Seen as Torture," *Innovation* (blog), *NBC News*, August 29, 2007, accessed March 29, 2015, http://www.nbcnews.com/id/20497575/ns/technology_and_science-innovation/t/energy-beam-weapon-could-be-used-iraq/#.VRiWg1I5C71.

¹²³ Lynn Fisher, "Turning up the Heat Demonstration Represents Highest Power Ever Documented by a Laser Weapon of Its Type: Latest Evolution of Lockheed Martin Laser Weapon System Stops Truck in Field Test," Lockheed Martin, March 3, 2015, accessed March 29, 2015, <http://www.lockheedmartin.com/us/news/press-releases/2015/march/ssc-space-athena-laser.html>.

¹²⁴ "Today's Directed Energy Weapons - Meeting the Realities of Power, Heat, Size and Inclination," *Military Technology*, March 20, 2014, accessed March 29, 2015, <http://www.miltechmag.com/2014/03/todays-directed-energy-weapons-meeting.html>.

restrictive terrain.¹²⁵ Also, Boston Dynamics' 6 foot, 300 lbs "Atlas II" humanoid robot, which according to *Popular Mechanics* is the most advanced humanoid robot in the world.¹²⁶ Despite these technological advancements, the US Army has not encouraged its combat experienced officer force to participate in creative collaboration concerning how such systems may be employed. The German case study revealed how the *Reichswehr* emphasized tanks in their training maneuvers, even as the Versailles treaty strictly forbade them from possessing actual tanks.

During Operation Iraqi Freedom and Operation Enduring Freedom, the US Army substantially increased the number of ground robotic platforms available for use at the tactical level. The majority of these ground robotic systems such as PackBot, MARCbot, TALON, MAARS and SWORDS were strictly operated by humans via remote control, and were primarily applied to directly counter the threat of improvised explosive devices (IEDs).¹²⁷ Due to overarching policy concerns, the operators of armed ground robots such as the Special Weapons Observation Reconnaissance Detection System (SWORDS) were not authorized to engage their respective weapons in support of maneuver operations.¹²⁸ In 2010, largely due to the rapid increase in these commercial off-the-shelf (COTS) robotic systems technology used in support of OEF and OIF, the director of the Army Capabilities Integration Center (ARCIC) published a memorandum requiring Unmanned Ground Systems (UGS) to "...improve in the areas of modularity, autonomy, interoperability, coordination, and collaboration across the Network...", and

¹²⁵ "LS3 - Legged Squad Support Systems," Boston Dynamics, accessed March 29, 2015, http://www.bostondynamics.com/robot_ls3.html.

¹²⁶ Davey Alba, "The First Responder That Goes Where Humans Cannot: The Pentagon's Humanitarian Humanoid Robot Will One Day Obviate the Need for Humans to Risk Their Lives After a Catastrophe.," *Popular Mechanics*, October 7, 2014, accessed March 29, 2015, <http://www.popularmechanics.com/technology/robots/a13085/the-first-responder-that-goes-where-humans-cannot-breakthrough-awards-2014/>.

¹²⁷ Singer, *Wired for War*, 32.

¹²⁸ William Matthews, "Robot or Not?," *ARMY Magazine*, November, 2014, 37, accessed March 30, 2015, http://www.ausa.org/publications/armymagazine/archive/2014/Documents/11November14/Matthew_November2014.pdf.

announced the development of an UGS campaign plan 2010-2035.¹²⁹ Additionally, a Joint Ground Robotics Integration Team (JGRIT) summit convened to explore potential applications for UGS.¹³⁰

Subsequently, in 2013, the Robotic Systems Joint Project Office (RSJPO) published its Unmanned Systems Integrated Roadmap FY2013-2038, which provides a comprehensive analysis of DoD concerns for all unmanned systems designed to operate autonomously within the terrestrial, maritime, aerospace, and space domains.¹³¹ While this document serves as an excellent reference addressing the resourcing, acquisition, maintenance, and UGS Programs of Record (POR) to enhance Protection, Sustainment, and Mission Command warfighting function capabilities, there is little mention of PORs for armed ground robots designed to enhance maneuver capability in the direct ground combat role.¹³² This evidence indicates a top-down approach to development and employment similar to the interwar French Army's rigid development of methodical battle doctrine. The US Army emphasized procurement procedures and cost efficiency when building its initial ground robotic force. This resembles the French Army's decision to adhere to their pre-existing light armor capabilities from WWI, and is in contrast to the German Army who built their mechanized force around doctrinal vision of employment.

A January, 2014 publication by the US Army Combat Studies Institute outlines the potential for autonomous robotic systems to operate in one of three major capacities: sensors, (reconnaissance),

¹²⁹ Donald M. Sando, (Director of Capabilities Development and Integration), Memorandum to Director(s) of CDID, *Unmanned Ground Vehicle Strategy*. July, 28 2010, accessed March 31, 2015, <http://www.ndia.org/Divisions/Divisions/Robotics/Documents/UGV%20Strategy%20Memo.pdf>

¹³⁰ Jeff Jaczkowski, "Equipping Joint Warfighters through Modernization of Unmanned Ground Systems (UGS)," *Defense AT&L Magazine*, July-September 2010, 19, accessed March 30, 2015, [http://asc.army.mil/docs/pubs/alt/2010/3_JulAugSep/articles/17_Equipping_Joint_Warfighters_Through_Modernization_of_Unmanned_Ground_Systems_\(UGS\)_201003.pdf](http://asc.army.mil/docs/pubs/alt/2010/3_JulAugSep/articles/17_Equipping_Joint_Warfighters_Through_Modernization_of_Unmanned_Ground_Systems_(UGS)_201003.pdf).

¹³¹ *Unmanned Systems Integrated Roadmap FY 2013-2038* (Washington D.C.: US Department of Defense, 2013), vii, accessed March 30, 2015, <http://www.defense.gov/pubs/DOD-USRM-2013.pdf>.

¹³² Ibid.

shooters (maneuver), and servants (logistics).¹³³ Given this framework, the US Army appears to be advancing its UGS capabilities in the *sensor* and *servant* roles far more than in the *shooter* role. Example of *sensors* include phasing out its OH-58 Kiowa Warrior helicopters in favor of increased Levels of Integration (LOI) directly between AH-64 Apache helicopters and Grey Eagle or Shadow Unmanned Aerial Systems (UAS).¹³⁴ An example of *servants* includes recent field testing of driverless vehicle convoys conducted by the Tank Automotive Research Development and Engineering Center (TARDEC) at Fort Hood, Texas.¹³⁵ During these tests, autonomous vehicle convoys successfully completed military line-haul missions through controlled urban and rural terrain environments.¹³⁶ Additionally, ARCIC has initiated steps for fielding *sensor* capability such as the Common Light Autonomous Robotics Kit, (CLARK) which consists of man-portable quad-copter drones and small tracked vehicles to enhance situational awareness for dismounted squads.¹³⁷ The US Army Medical Research and Materiel Command explored practical applications for *servants* such as the Battlefield Extraction Assist Robot (BEAR), designed to autonomously navigate buildings and obstacles to extract wounded Soldiers.¹³⁸ These examples illustrate ongoing advancements in *sensor* and *servant* robotic systems, and appear to leverage

¹³³ Michel Yakovlev, "Battlefield Robotization: Toward a New Combat Ecosystem," in *Robots on the Battlefield: Contemporary Issues and Implications for the Future*, ed. Ronan Doare, Didier Danet, JP Hanon, G. Boisboissel (Fort Leavenworth, KS: Combat Studies Institute Press, 2014), 247.

¹³⁴ Valerie Insinna, "Importance of Manned-Unmanned Aircraft Teams to Grow as Army Divests Kiowa Warriors," *National Defense Magazine*, January, 28 2015, 1, accessed March 30, 2015, <http://www.nationaldefensemagazine.org/blog/Lists/Posts/Post.aspx?ID=1726>.

¹³⁵ Bruce J. Huffman "Autonomy-Enabled Technology Provides a Pathway to the Future," *ArmyTechnology Magazine*, November-December 2014, 1, accessed March 30, 2015, <http://armytechnology.armylive.dodlive.mil/index.php/2014/10/31/autonomy-enabled-technology-provides-a-pathway-to-the-future/>.

¹³⁶ Huffman "Autonomy-Enabled Technology Provides a Pathway to the Future," 1.

¹³⁷ Matthews "Robot or Not?" 35.

¹³⁸ Ellen M. Purdy, "The Increasing Role of Robots in National Security," *Defense AT&L Magazine*, May-June 2008, 28, accessed March 30, 2015, http://www.acq.osd.mil/asda/docs/articles/the_increasing_role_of_robots_in_national_security.pdf.

emerging technology in strictly an auxiliary capacity. The paradigm of human combatants as the primary means of waging ground combat is not fundamentally changed. This evidence indicates that the US Army seeks to leverage semi-autonomous robotics in a strictly auxiliary capacity. In this respect, it closely resembles the interwar French Army's early reluctance to adopt armored divisions and corps because they chose to employ their tanks dispersed among Infantry formations.¹³⁹

To date, the DoD has published numerous descriptive references that identify the need for innovation with autonomous robotic systems, but there are few references which actually provide prescriptive information concerning methods the US Army will explore to leverage the full technological capabilities of autonomous ground robotic weapon systems into its maneuver doctrine. One recent article concerning niche capability gaps within the PACOM and SOUTHCOM AORs explained, "The existing methods for conducting a mission with manned equipment cannot simply be continued with a robot replacing a person. New operational concepts need to be created based on an understanding of both the capabilities and limitations of the robot".¹⁴⁰ While describing the future operational environment, the US Army Capstone Concept, TRADOC Pam 525-3-0 conveys, "Emerging technologies such as autonomous systems, social media, alternative power and energy solutions, and biometrics will become more widespread and have a growing impact on military effectiveness. Anticipating how people apply technology will continue to be as important as the technologies themselves".¹⁴¹ Yet there is no appreciable mention of robotics or of autonomous weapon systems within the reference. Similarly, the US Army Operating Concept 2020-2040, TRADOC Pam 525-3-1 outlines five characteristics of the future operational environment expected to significantly impact land operations, of which autonomous

¹³⁹ Bond, "Liddell Hart and De Gaulle," 610.

¹⁴⁰ Ibid.

¹⁴¹ *TRADOC Pam 525-3-0: The U.S. Army Capstone Concept* (Fort Eustis, VA: U.S. Army Training and Doctrine Command, 2012), 9, accessed March 29, 2015, <http://www.tradoc.army.mil/tpubs/pams/tp525-3-0.pdf>.

robotic weapons systems are not mentioned.¹⁴² A subsequent appendix within the document discusses the impacts that UGS will have on protection, sustainment, and intelligence capabilities, but there is no explicit reference to robotic ground weapon systems in the maneuver role.¹⁴³

Current evidence suggests that the US Army has not yet formally explored innovation with ground robotic weapon systems in a way that might supersede the existing paradigm of human combatants as the primary *shooter* system on the battlefield. According to recent ARCIC publications, modernization efforts such as LandWarNet, Warfighter Information Network-Tactical (WIN-T)-2, and establishing the Integrated Training Environment (ITE) remain clear priorities for the force.¹⁴⁴ A published list of the training objectives guiding the Network Integration Evaluation (NIE) 15.1 conducted at FT Bliss, Texas and White Sands Missile Range, New Mexico in 2014 does not include experimental concepts for the tactical employment of autonomous ground robotic weapon systems. In a November 2014 article published in Army magazine, the ARCIC research and development chief stated, “The Army is not looking to replace Soldiers with robots”.¹⁴⁵ Within the same article, the director of TARDEC conveyed that robots will merely “augment the performance and effectiveness” of Soldiers, while the director of ARCIC’s Information Integration Directorate added, “There can be no decision to kill without a human in the loop”.¹⁴⁶ According to the ARCIC, the overall intent for Force 2025 is to perhaps achieve robotic ground weapon systems that could be directly supervised a human counter-part in a “wingman”

¹⁴² *TRADOC Pam 525-3-1: The U.S. Army Operating Concept: Win in a Complex World 2020-2040* (Fort Eustis, VA: US Army Training and Doctrine Command, 2014), 11, accessed March 30, 2015, <http://www.tradoc.army.mil/tpubs/pams/TP525-3-1.pdf>.

¹⁴³ *Ibid.*

¹⁴⁴ Stephen Murray, “LandWarNet Remains a Top Modernization Priority,” Army Capabilities Integration Center, June 20, 2014, accessed March 29, 2015, <http://www.arcic.army.mil/Articles/cdd-LandWarNet-Remains-A-Top-Modernization-Priority.aspx>.

¹⁴⁵ Matthews “Robot or Not?” 35.

¹⁴⁶ *Ibid.*, 35-36.

concept.¹⁴⁷ The Army Operating Concept (AOC) also refers to this approach as “manned-unmanned teaming”.¹⁴⁸ Such an approach potentially limits the full capabilities of emergent technological systems by funneling advanced components into a pre-existing paradigm. Again, the evidence reveals that the US Army’s current approach for developing autonomous robotic weapons is congruent with the interwar French Army’s approach for developing its mechanized doctrine. The French adhered to the 1921 directive of Marshal Petain that emphatically stated, ““Tanks assist the advance of the infantry, by breaking static obstacles and active resistance put up by the enemy””.¹⁴⁹ The French Army possessed technologically advanced equipment, but did not recognize a need to adjust its paradigm of employment.

Further evidence that the US Army’s approach currently resembles that of the interwar French Army can be found in the 2014 ARCIC white paper on the Army Vision - Force 2025, which clearly outlines the necessity of utilizing science and technology to create and sustain a leaner, expeditionary force capable of preserving overmatch against potential near-peer adversaries.¹⁵⁰ However, there is only a single sentence that explicitly references ground robotics, noting robots may “Enable and augment humans to accomplish ultra-hazardous tasks”.¹⁵¹ According to robotics expert Dr. Robert Finkelstein, by 2035 the technology will be available for autonomous robots to supersede human combatants as the primary *shooter* system on the battlefield.¹⁵² “Technology is not the main impediment to building a much more robotic military. We could do it right now with the current technology but we have to have the

¹⁴⁷ Matthews “Robot or Not?” 35-36.

¹⁴⁸ *TRADOC Pam 525-3-1: The U.S. Army Operating Concept: Win in a Complex World 2020-2040* (Fort Eustis, VA: US Army Training and Doctrine Command, 2014), 37, accessed March 30, 2015, <http://www.tradoc.army.mil/tpubs/pams/TP525-3-1.pdf>.

¹⁴⁹ Horne, *To Lose a Battle*, 79.

¹⁵⁰ *Army Vision - Force 2025 White Paper* (Fort Eustis, VA: US Army Capabilities Integration Center, 2014), 1-9, accessed March 31, 2015, http://www.arcic.army.mil/app_Documents/USArmy_WhitePaper_Army-Vision-Force-2025_23JAN2014.pdf.

¹⁵¹ *Ibid.*, 6.

¹⁵² Matthews “Robot or Not?” 37.

motivation to do it...The ground stuff is pretty much where UAVs were 20 years ago”.¹⁵³ Although ARCIC future has identified and published a list of six robotic-integration challenges, the development of autonomous, armed ground robots for direct combat is not stated as a current, or planned priority listed within these.¹⁵⁴

Evidence suggests that the US Army has recognized cost saving applications for robotics, however the current emphasis appears to be only on the development of autonomous robotic capabilities in a strictly auxiliary capacity. These appear to be limited to improvements in protection, intelligence, and sustainment capabilities only. In other words, the Army appears to be actively pursuing advanced developments of *sensors* and *servants*, but not of *shooters*. One limitation is found in DoD policy 3000.09 which governs autonomous weapons systems, and strongly discourages mechanical means of directly targeting of humans.¹⁵⁵ Based on this evidence, it is apparent that developing a cognitive, doctrinal approach to fully integrating armed robotic ground weapon systems into maneuver doctrine is not a current or planned priority for the US Army.

The organization adheres to the paradigm that demands human combatants remain the exclusive autonomous *shooters* on the battlefield. Thomas Kuhn’s observations on scientific revolutions suggest that innovation beyond this current paradigm is not likely to occur, without an increased perception of crisis by the institution.¹⁵⁶ There is strong evidence to support the parallels between the interwar French Army’s efforts toward mechanized warfare, and the US Army’s contemporary approach toward

¹⁵³ Matthews “Robot or Not?” 37.

¹⁵⁴ Dave Shunk, “The Rise of Robot Warfare Integrating Semi-Autonomous Combat Robots in Future Land Warfare: U.S. Army Planning Has Already Begun,” Army Capabilities Integration Center, September 13, 2013, accessed March 30, 2015, <http://www.arcic.army.mil/Articles/cdlld-The-Rise-of-Robot-Warfare-US-Army-Planning-has-Already-Begun.aspx>.

¹⁵⁵ “U.S. Department of Defense Directive Number 3000.09 Autonomy in Weapon Systems,” Defense Technical Information Center, November 21, 2012, accessed March 30, 2015, <http://www.dtic.mil/whs/directives/corres/pdf/300009p.pdf>.

¹⁵⁶ Kuhn, *The Structure of Scientific Revolutions*, 66.

autonomous robotic ground weapons systems. Both armies possessed a wealth of combat experience, and faced the challenges of fiscal constraints in the post war environment. Both armies considered themselves to be the premier land power in the world, and therefore neither generated sufficient incentive to risk transcending institutional paradigms concerning the application, integration, and employment of emergent technological capabilities on the battlefield. In sharp contrast, the German *Reichswehr* recognized that it could not succeed in supporting their national interests through another stagnated war of attrition. Because of this sense of crisis, they were compelled to find ways to innovate with emergent technology in order to restore their offensive mobility. As Thomas Kuhn's theory describes, the US Army does not perceive itself to be facing a crisis in the decades ahead, and therefore (like the interwar French Army) will not likely be receptive to innovation beyond its current paradigm.

Conclusion

The only thing harder than getting a new idea into the military mind is to get an old one out.¹⁵⁷

- B.H. Liddell Hart

The art of progress is to preserve order amid change and to preserve change amid order.¹⁵⁸

- Alfred N. Whitehead

Every so often in history, you get a technology that comes along that's a game changer. They're things like gunpowder, they're things like the machine gun, the atomic bomb, the computer... and robotics is one of those.¹⁵⁹

-Peter W. Singer

The evidence indicates that rapid advancements technological capabilities, combined with ongoing changes in the global operational environment are increasingly rendering many of the paradigms of warfare in the twentieth century obsolete. This seems to be particularly true regarding autonomous ground robotic weapon systems. In 2014, a paper published by the Brookings Center for Technological Innovation identified the increasing considerations and US societal concerns regarding contemporary social-robotics integration and it revealed that “Human cultural response to robots has policy implications. Policy affects what we will and will not let robots do. It affects where we insist on human primacy and what sort of decisions we will delegate to machines.”¹⁶⁰ In the same paper, the author compares and contrasts various international cultural perspectives concerning autonomous robotic

¹⁵⁷ Stephen J. Gerrass and Leonard Wong, “Changing Minds in the Army” (thesis, U.S. Army War College, 2013), 1, accessed March 30, 2015, http://www.au.af.mil/au/awc/awcgate/army-usawc/changing_minds_in_the_army_3jun13.pdf.

¹⁵⁸ “Dr Robert Finkelstein,” Robotic Technology Inc., accessed March 30, 2015, <http://www.roboticstechnologyinc.com/index.php/robertfinkelstein>.

¹⁵⁹ Jason Mick, “Military Contractors Take a Step Forward Towards Autonomous Killer Robot Swarm,” *Daily Tech - Science* (blog), March 5, 2013, accessed April 2, 2015, <http://www.dailytech.com/Military+Contractors+Take+a+Step+Forward+Towards+Autonomous+Killer+Robot+Swarm/article30047.htm>.

¹⁶⁰ Heather Knight, “How Humans Respond to Robots: Building Public Policy through Good Design, Carnegie Mellon Institute,” Brookings, *The Robots Are Coming: The Project on Civilian Robots*, July, 2014, 2, accessed April 2, 2015, <http://www.brookings.edu/~media/Research/Files/Reports/2014/07/29-how-humans-respond-to-robots-knight/HumanRobot-PartnershipsR2.pdf?la=en>.

technology. For instance, in Japan the concept of advanced autonomous robotics is warmly embraced and encouraged, while in the United States autonomous humanoid robots are generally feared and mistrusted.¹⁶¹ The paper further provides evidence illustrating how cultural paradigms may potentially serve as cognitive barriers to innovation. Similarly, it also suggests the importance of understanding varying international perspectives, (including those of non-state actors), and changing paradigms concerning the use of ground robotic weapon systems to wage ground combat in the 21st Century.

In his book, *The Culture of Military Innovation*, Dr. Dima Adamsky (Lauder School of Government, Diplomacy, and Strategy) elaborates on the impact of cultural and institutional norms on doctrine and military technology and he explains, “A national cognitive style is one element in the cultural mosaic that shapes a state’s strategic behavior and constitutes the ideational foundation of its military innovation”.¹⁶² Adamsky explains that one may consider military institutions in three distinct and overlapping phases: speculation, experimentation, and implementation.¹⁶³ Using such a construct, the evidence reveals that the US Army appears to be in the nascent stages of the speculation phase, and is not likely to proceed into the second and third phases concerning autonomous ground weapon systems development because, as Kuhn’s theory suggests, its present paradigm still appears to answer the problems of old science.

Such cognitive barriers are particularly relevant when considered in the context of the accelerating proliferation of autonomous robotic technology (to both state and non-state actors) and the active global trends toward urbanization into megacities. Presently, over fifty percent of the global population lives inside urban areas, and an estimated 180,000 people continue to migrate from rural to

¹⁶¹ Knight, “How Humans Respond to Robots”, 7.

¹⁶² Dima Adamsky, *The Culture of Military Innovation: The Impact of Cultural Factors On the Revolution in Military Affairs in Russia, the US, and Israel* (Stanford, CA: Stanford University Press, 2010), 15.

¹⁶³ Ibid., 20.

urban areas daily.¹⁶⁴ In fact, a recent article published in the *Small Wars Journal* anticipates that by the year 2030, over 70 percent of the human population will likely reside inside of cities.¹⁶⁵ Further, in a 2014 report examining the US Army's capacity to operate inside megacities, the Chief of Staff of the Army, Strategic Studies Group concluded that, "It is the assertion of this group that megacities are unavoidable, the Army must lead the national response, and the institution is currently unprepared".¹⁶⁶ The same report also concluded that the current doctrinal approach presented in FM 3-06 *Urban Operations* is whole insufficient because megacities themselves present "a fundamentally new operating environment to which the Army must shape itself and discover new approaches".¹⁶⁷ Although the US Army has identified potential anomalies that Kuhn describes, the organization does not yet appear to have developed sufficient level of perceived crisis to facilitate paradigm evolution. The evidence shows that current cultural paradigms impact the US Army's efforts to innovate in a manner that is consistent with the French Army during the interwar period 1919-1939.

One final analogy that underscores this importance of the phenomenon of innovation is found by examining the recent tactics of violent extremist organizations during Operation Iraqi Freedom. By adapting readily available low-cost commercial electronic components such as timers, hand-held radios, electric switches, and cellular phones with home-made explosives materials these groups employed numerous varieties of Improvised Explosive Devices (IEDs), in order to effectively disrupt the freedom of

¹⁶⁴ William Mathews, "Megacity Warfare: Taking Urban Combat To a Whole New Level," *ARMY Magazine*, March, 2015, 31.

¹⁶⁵ David Shunk, "Mega Cities, Ungoverned Areas, and the Challenge of Army Urban Combat Operations in 2030-2040," *Small Wars Journal* (January, 23 2014): 1, accessed April 2, 2015, <http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CB8QFjAA&url=http%3A%2F%2Fsmallwarsjournal.com%2Fprintpdf%2F15177&ei=13odVYqlHISggwSitoCwCQ&usg=AFQjCNFg7crVMwD-I2Do8Jc99dxFPJZXCA&bvm=bv.89744112,d.eXY>.

¹⁶⁶ Megacities Concept Team, *Megacities and the United States Army: Preparing for a Complex and Uncertain Future* (Arlington, VA: Chief of Staff of the Army, Strategic Studies Group, 2014), 8-9, accessed April 2, 2015, <http://usarmy.vo.llnwd.net/e2/c/downloads/351235.pdf>.

¹⁶⁷ *Ibid.*, 21.

movement of coalition forces, and triggered the critical investment of nearly \$18 billion worth of immediate Joint Improvised Device Defeat Organization (JIEDDO) funding 2006 – 2011.¹⁶⁸ Similarly, by adapting crude variants of autonomous robotic weapons, black-marketed directed energy weapons, and or commercially available software, potential adversaries may find creative ways exploit the critical vulnerabilities of coalition security forces. Last year, the Center for New American Security (CNAS) published a comprehensive report that describes the confluence of this emergent technology and its impact on the operational environment within the next decades:

Other emerging technologies may disrupt the global military balance as well, such as offensive cyber warfare tools; advanced computing; artificial intelligence; densely interconnected, multi-phenomenology sensors; electric weapons such as directed energy, electromagnetic rail guns and high-powered microwave weapons; additive manufacturing and 3-D printing; synthetic biology; and even technologies to enhance human performance on the battlefield. All of these technologies –driven primarily by demand and advances in the commercial sector – are emerging today...¹⁶⁹

Despite these dynamic changes to the contemporary OE, an FY12 Army Science Board study revealed that commercial R&D has consistently outpaced government R&D by 180% over the last five decades and the report concluded, the...“DOD and the Army have lost the ability to ensure technological dominance through internal R&D, because adversaries are able to exploit commercially available technologies on a global scale”.¹⁷⁰ The French Army was considered the dominant land power until its adversaries innovated with available technology to obtain a relative advantage. The US Army is currently the dominant land power, and emergent technology now offers a window of opportunity for innovation.

¹⁶⁸ Cary B. Russell, *Counter-Improvised Explosive Devices: Multiple DoD Organizations Are Developing Numerous Initiatives* (Washington D.C.: Government Accountability Office, 2012), 1, accessed April 2, 2015, <http://www.gao.gov/assets/600/593242.pdf>.

¹⁶⁹ Robert O. Work and Shawn Brimley, “20YY Preparing for War in the Robotic Age,” Center for a New American Security, January, 2014, accessed April 2, 2015, http://www.cnas.org/sites/default/files/publications-pdf/CNAS_20YY_WorkBrimley.pdf.

¹⁷⁰ *The Strategic Direction for Army Science and Technology* (Washington DC: Department of the Army; Army Science Board, 2013), 2, accessed April 15, 2015, <https://fas.org/irp/doddir/army/asb-strat.pdf>.

The evidence of this research project suggests that the preponderance of US Army's combat-experienced maneuver officer corps are not formally engaged, nor significantly encouraged to become formally involved in a deliberate process identify recommended procedures, or creative approaches to innovate with autonomous robotic technology in ways that might transcend 20th century paradigms. A feature film released by Sony Pictures in 2015, *Chappie*, reflects the increasing concerns of autonomous robotic technology within US society and contains several scenes depicting ways fictional robotic ground weapon systems might be employed in ground combat.¹⁷¹ One of the underlying themes of film is the cognitive barriers to autonomous robots as the film illustrates an unarmed autonomous robot's ability to think, adapt, and defeat a vastly technologically superior and heavily armed military robot controlled directly by a human operator via remote control. Though the depiction is clearly fictional, it creatively offers points of consideration for US Army officers concerning the best employment of autonomous robotic ground weapon systems in the next decades. As General Hans von Seeckt once stated, *die Gedanken sind Frei* ("thoughts are free").¹⁷²

In conclusion, the evidence supports the hypothesis that US maneuver officers are not fully anticipating the requirement to train, equip, and fully integrate the force with autonomous robotic ground weapon systems. Nor is there a formal incentive for the Army, as an institution, to fully anticipate requirements to field and development these systems or to envision a comprehensive doctrine to harness their full capabilities to gain a position of relative tactical advantage over the nations adversaries.

As Carl von Clausewitz stated, "War is thus an act of force to compel our enemy to do our will."¹⁷³ Inherently, it is likely that human combatants will remain the most vital component of ground combat. Yet, as the evidence reveals, the pace of tactical operations is increasingly poised to exceed the

¹⁷¹ "Chappie 2015," IMDb, accessed April 15, 2015, <http://www.imdb.com/title/tt1823672/>.

¹⁷² Citino, *Blitzkrieg to Desert Storm*, 33.

¹⁷³ Carl von Clausewitz, *On War*, ed. and trans. Peter Paret and Michael Howard (Princeton, NJ: Princeton University Press, 1989), 75.

cognitive paradigms of twentieth century warfare. Thomas Kuhn's theory reveals that the perception of crisis is often required before institutions are able to transcend old science paradigms and to truly innovate. A comparison of the German, French, and US Army case studies revealed that the development of advanced technological weapon systems is not as critical to success, as how exactly those weapon systems are employed against the enemy force. Perhaps it is this very notion that US Army planners must fully appreciate when preparing the operational force to dominate ground combat operations in the twenty-first century.

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